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Verification of Fixed Offshore Oil and Gas Platforms

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VERIFICATION OF FIXED OFFSHORE OIL AND GAS PLATFORMS:

An Analysis of Need, Scope, and Alternative Verification Systems.

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A report prepared by the Panel on Certification of Offshore Structures of the Marine Board, Assembly of Engineering, National Research Council

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NATIONAL ACADEMY OF SCIENCES
Washington, D.C., 1977

NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Panel responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by the Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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SUMMARY

America's demand for energy is now growing at 2.5 percent a year, according to the Federal Energy Administration, and its dependence on foreign oil is increasing rapidly -- from 26 percent before the 1973 oil embargo to 46 percent in February 1977. One important source of new oil and gas reserves lies off the coasts of the U.S. This offshore region, only about 2 percent of which has been opened for production, provided 16.4 percent of the nation's oil and 14 percent of its natural gas in 1975, and according to the predictions of the American Petroleum Institute, by 1985 the yield could double.

In the near future, exploration and production will be extended from the principal sites of present offshore oil and gas reserves in the Gulf of Mexico and offshore Southern California to the Gulf of Alaska and the Atlantic and Arctic Oceans, where storm, seismic, and geological conditions are different. The projected increase in such oil and gas recovery from the U.S. outer continental shelf (OCS) has intensified public and government concerns about conserving vital resources, protecting the environment, and safeguarding human life.

The U.S. Geological Survey (USGS) regulates OCS technology and other activities principally by issuing OCS orders and other lease stipulations. Since 1971, several studies conducted by the USGS, the Marine Board of the National Academy of Engineering, the General Accounting Office, the President's Council on Environmental Quality, and the Congress' Office of Technology Assessment have concluded with recommendations for regulating and inspecting the lessees engaged in offshore oil and gas production.

Accordingly, the USGS requested the National Research Council to undertake a review of the practices in the verification of the structural adequacy of fixed offshore oil and gas platforms -- that is, the production facilities permanently fixed to the seabed by pilings, spread footings, and other means. The USGS also requested a review of the need for establishing a third-party verification procedure and, if this was deemed necessary, how such a procedure might operate. To perform this study, the National Research Council assigned the Marine Board (which had been transferred from the National Academy of Engineering in 1974 to conduct such projects), which in turn, appointed a special panel that initiated this study in January 1976.

The record for oil and gas platforms operating off U.S. coasts in the past three decades is exceptionally good. Of 3,000 structures erected between 1947 and 1975 in the Gulf

of Mexico, storms accounted for the destruction of only 26 and partially damaged another 11. While oil spills have resulted from storms or from such other causes as collisions, fires, blowouts, or storage tank ruptures, no significant spills have been attributed by the USGS and the U.S. Coast Guard to failures of the platform structures. The most publicized spill involving a platform in U.S. waters, the incident in the Santa Barbara Channel off Southern California in 1969, was due to the nature of the subbottom geology and to leakage around the well casing rather than any structural deficiency of the platform. Since then, as the Council on Environmental Quality has observed in its 1974 report, OCS Oil and Gas, "the offshore oil and gas industry has made substantial progress in technology and work practices." The record of offshore platform operations in the past three decades also shows that no lives were lost from structural failures.

In its earliest deliberations the panel concluded that no verification procedure could guarantee that a fixed offshore oil and gas production platform will be safe or secure at all times for operating personnel, that it will withstand the effects of all storms, collisions, or other accidents of nature or man, and that it will preserve the environment. Even so, verification provides a practical way of giving additional and more credible assurance to the public and the governments (at state and national levels) that all reasonable precautions have been taken, based on the best applicable technical and environmental knowledge available, to ensure the integrity of the structure, so that oil and gas platforms on the OCS offer safety to the personnel, protection of the environment, and conservation of the resources.

The present verification procedure calls for the offshore oil and gas industry, under the general supervision of the USGS, to oversee and regulate the structural integrity and operational safety of all drilling operations at sea as well as of the production equipment associated with the platforms. The industry does this by requiring that the structures are designed to withstand the operational loads and environmental forces likely to occur. The design of the structure is certified by a registered professional engineer.

The panel reviewed the verification systems now in use for offshore structures in waters around the U.S. and abroad (as well as other types of structural certification) in order to determine the advantages and disadvantages of each. Based on its examination of such systems, the panel concluded

that a verification system should include the following principal elements:

- Establishment of environmental conditions for each area and class of structure;
- Documentation and promulgation of the recommended practices for design and construction;
- Submission and approval of the verification plans;
- Conducting the verification procedure throughout the design, fabrication and installation;
- Allowance for appeals of the system;
- Provision for reporting and investigation of accidents; and,
- Maintenance of an audit of the system.

In addition, the system must be sufficiently flexible to provide for variations in environmental design conditions and to allow for the introduction of new technology. Further, it should be so structured as to minimize any delays that might occur in the process of platform design approval, construction, and installation.

The panel weighed the benefits and possible adverse effects of a third-party verification system. The principal benefit of such a system is to enhance the orderly extension of OCS oil and gas activities in an expeditious and efficient way by assuring the public and the Congress of the integrity of the fixed offshore platforms. Potential adverse effects include excessive delays and interruptions to the step-by-step process of design and construction, excessive rigidity, and over-reliance on codes or standards that may prevent the introduction of advanced technology. On balance, the panel concluded that the benefits, advancing the capability to proceed in an orderly manner, outweigh the adverse consequences of third-party verification.

Therefore, the panel recommends that a third-party verification system should be implemented by the USGS for future production platforms in all U.S. waters. In making this recommendation, the panel recognized that the establishment of a verification procedure requires a major commitment on the part of the USGS and the government, particularly in

recruiting and training an adequate and technically competent in-house staff to administer the system.

When the system is fully developed, the verification of design, fabrication, installation, and maintenance can best be performed by independent third-party agents, selected on the basis of technical competence and experience in offshore engineering. Such third-party agents should not have corporate affiliation with the owner or operator of the platform; nor should they be allowed to verify any function or structure for a specific platform with which they, their company, or any corporate affiliate are connected.

The panel recommends a transition period during which the verification procedure is implemented. The purpose of the transition period is to avoid a disruption of the present development of the OCS and to utilize existing technical expertise fully. Unreasonable delays can be costly and increase the nation's dependency on foreign oil and gas. Only when the USGS is staffed adequately and criteria and environmental data for specific regions have been established should the verification procedures used in the transition period be expanded to the full third-party verification system that the panel proposes.

The panel recommends that the USGS establish a board of consultants to develop and review environmental design conditions, practices for design and construction, verification procedures, and qualifications for third-party reviewers. The membership of such a board would be sufficiently broad to ensure that critical decisions are not based on narrow considerations.

The panel also recommends the use of outside contractors to support the system while, at the same time, to limit the need for an overly large USGS staff. Notwithstanding, the management and administration of the entire verification procedure is a function of the USGS and cannot be delegated.

In addition, the panel offers related recommendations:

° The USGS should prepare policy guidelines defining the elements of the verification procedure and how it is to be implemented;

° The USGS should provide guidelines for the submission of acceptable verification plans by the owner or operator on individual projects;

- The USGS should take positive steps to ensure that research programs necessary to resolve technical uncertainties arising from verification are initiated;

- The USGS should establish procedures for the routine reporting of platform structural conditions and analysis;

- An independent, impartial board should be utilized to review accident investigations;

- The USGS should encourage its personnel to maintain their technical competence by participating in professional society activities and continuing education programs;

- The federal government should provide adequate funding for the adoption and administration of the proposed verification system; and,

- A periodic review of the established verification system should be instituted.

In the course of its study, the panel was aware that the USGS, under its present statutory basis, has responsibility for the prevention of waste and conservation of natural resources. The legal authority of USGS responsibility for the safety of structures and protection of the environment is not clear. Therefore, the statutory basis for the operation of the verification program, under the USGS, needs clarification.

Although costs were not a major consideration, the panel's best estimate of costs is approximately 1 percent of cost of the total platform for meeting the expense of USGS personnel to administer and monitor the system and 2 percent of the cost of the platform to meet the outlay of industry for documentation, reviews, and inspection. The cost of each major platform in new U.S. waters varies in a range from $30 million to $150 million.

PANEL ON CERTIFICATION OF OFFSHORE STRUCTURES

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INTRODUCTION

The magnitude of a verification program for offshore oil and gas structures can be estimated on the basis of the number of existing platforms. Since 1947, more than 3,000 offshore oil and gas production platforms have been erected on the outer continental shelf (OCS) around the U.S., mostly in the Gulf of Mexico. Approximately 50 more structures are now being built for installation in U.S. waters.[1]

The history of offshore platform structural integrity is described in papers by G. C. Lee and Bernhard Stahl, and in presentations to the panel by Lyle S. St. Amant and the Offshore Operators' Committee.[2,3] The record shows that as offshore experience in structure design has increased, damages to structures have decreased, even though work has extended to greater depths in the oceans. Stahl states that this is largely a result of continual improvements in industrial design and construction and work practices. About 850 major platforms and 2,200 lesser structures were installed in the Gulf of Mexico between 1947 and 1975. Of these, major hurricanes completely destroyed only 26. Eleven others were damaged, but could be salvaged and repaired. Few of the destroyed structures embodied modern design practices. There is no record that any lives were lost as a result of structure failures from the storms. Furthermore, no major oil spills in the Gulf have been attributed to structural failure.

The outlook is for increasing the pace of development for offshore oil and gas to meet the demand for these fuels that cannot be met by onshore development in the United States. It is estimated that from 20 to 35 platforms will be installed each year during the next five or six years, about half of these to be erected in the waters off Alaska or in the Arctic. Such structures must be built to withstand storm and seismic conditions that do not exist in the Gulf of Mexico, where much of the offshore technology experience has been gained. Furthermore, many of them will be operated by 200 to 400 people who may find themselves cut off from rescue during severe storms at sea. Moreover, newly organized and possibly less experienced firms may be involved in such offshore exploration and production, thereby increasing the possibility of structural failures and accidents.

Concurrent with the expansion of offshore technology into harsher environments is a growing tendency of the public and the Congress to question the adequacy of safety provisions and environmental precautions in offshore recovery operations. Although unrelated to structural failures of fixed platforms, the loss of life and other accidents in North Sea oil and gas operations have called public attention to the hazards posed by hostile environments for man and structures. While the public recognizes that offshore production can augment the dwindling supplies of oil and gas required to heat their homes, fuel their cars, and operate their farms and industries, at the same time, it is increasingly sensitive to activities that affect human safety and damage the environment.

Leonard C. Meeker, in a working paper prepared for the panel, has noted several consequences of public interest in environmental safeguards. Thus, public reaction to the oil spill in the Santa Barbara channel off California in 1969 led the Department of Interior to halt further OCS oil and gas development in the area for several years. Even though the oil leakage resulted from the nature of the subbottom geology and leakage around the well casing, rather than structural deficiency of the platform, the event was a rallying point for many environmental groups who were seeking Congressional support for their concerns.

Public pressure brought about the National Environmental Policy Act (NEPA) of 1969, which has led to legal actions taken by environmental groups. As a result of public concern for environmental protection in the OCS, the federal government, in April 1973, deferred drilling on the Atlantic OCS and in the Gulf of Alaska until a study of the environmental impacts of oil and gas production in these areas could be carried out. The study was conducted during the following year by the President's Council on Environmental Quality (CEQ) in consultation with the Environmental Protection Agency and other federal agencies, the National Academy of Sciences, and the governors, legislators, and citizens of the coastal states involved.

In a report, issued in April 1974, the CEQ stated:

> Development of OCS oil and gas...poses major challenges to Federal management and regulatory agencies, to the states affected by the offshore activities, and to the oil industry. Risk of damage to the human and natural environment is an inseparable part of almost any development, including the

> OCS. The guiding principles must be to keep risks at an acceptable level and to balance risks with benefits. When a risk -- based on the current state of knowledge and technology -- appears to outweigh that of an available alternative for meeting the same objectives, we should not move ahead until we know more and can do better. When the risk is acceptable, we should proceed with caution and with a commitment to prevent or minimize damage. This means that the oil industry must have adequate technology and must use it safely, that Federal agencies must exercise their management and regulatory responsibilities to ensure that the oil industry meet its obligations, and the Federal, state, and local agencies must coordinate their efforts to minimize disruption of coastal communities and environments by those facilities and other development required to support offshore operations.[4]

During the year in which the CEQ study was conducted, other events abroad bore directly on the question of OCS oil and gas development in the frontier areas. In October 1973, war broke out in the Mideast, and as a consequence, the Arab states imposed embargoes of oil to several nations, including the United States. When the embargo ended in April 1974, the Organization of Petroleum Exporting Countries (OPEC) had established prices which were substantially higher.

In the meantime, the Administration had announced Project Independence with the stated purpose of making the United States independent of foreign oil and gas imports by 1980. To reach self-sufficiency, the pace of exploration and production of OCS oil and gas resources would have to increase.

But when foreign imports of even larger quantities of oil resumed, concern was again expressed by the public, members of Congress, and state governments that the federal government and the industry were rushing into OCS development without the necessary environmental studies and environmental safeguards. There were doubts that the USGS could effectively supervise and regulate OCS development because of its dependence upon the expertise, evaluation, and judgment of companies with a direct interest in developing OCS oil and gas resources. Furthermore, there were questions that the existing regulations developed for appli-

cation in the Gulf of Mexico would be appropriate in the Atlantic, off Alaska, and in other deep water regions.

BACKGROUND

The U.S. Geological Survey of the Department of the Interior is responsible for overseeing and regulating the structural integrity and operational safety of offshore petroleum drilling and production equipment as provided in the Outer Continental Shelf (OCS) Lands Act, August 7, 1953 [67 STAT.462; 43 U.S.C. 1331-1343].[5] In carrying out this responsibility, the USGS develops regulations, after soliciting public comments through announcement in the Federal Register, and issues them in the form of OCS Orders.

Overall, the OCS Orders System has improved over the years; however, the provisions pertaining to structural integrity have remained relatively unchanged. However, the National Academy of Engineering's Marine Board (now the Marine Board, Assembly of Engineering, National Research Council) in its report in 1972 questioned the validity of approvals or inspections by the government of a platform that are based on the personal standards and expertise of the reviewers, rather than on a system of objective-oriented regulations and an interpretive system of industry standards. Regarding structural integrity, the report stated:

> The Order [OCS Order Number 8, Approval Procedure for the Installation and Operation of Platforms, Fixed and Mobile Structures, and Artificial Islands] requires statements by the operator as to sizes and loads on structural members and piling and then requires "the following certification signed and dated with the title of the company representative:
>
> > Operator certified that this platform has been certified by a registered professional engineer and that the structure will be constructed, operated, and maintained as described in the application, and any approved modification thereto.

No criteria are given for the "registered professional engineer" to use in certifying the platform.[6]

Since that report was issued and as oil and gas operations have proliferated, the regulatory practices of the USGS have come under increased scrutiny by the Congress, the general public, and the petroleum industry. These facts as well as the projected expansion of petroleum operations into the hostile environments of the Gulf of Alaska and the middle and north Atlantic Ocean areas, led the USGS to re-examine the regulatory requirements pertaining to offshore platforms wherever they may be installed, to ensure the technical adequacy and safety of their design, construction, and operation.

Accordingly, on January 29, 1976, the U.S. Geological Survey published a draft "Notice to Lessees and Operators of Federal Oil and Gas Leases in the OCS, Gulf of Mexico Area." [Issued by the Oil and Gas Supervisor, Field Operations] in the Federal Register (Vol. 41, No. 20) concerning the requirements for third-party inspections to be performed on all drilling and production operations.[7] [Comments from the public were solicited.] The following excerpts from that notice state the purpose of third-party inspection and define third-party inspectors for drilling and production operations:*

> A. Purpose: The purpose of third-party inspections is to enhance the efforts, to identify undesirable trends, and to provide solutions to problem areas with respect to safety and pollution control in day-to-day operations. Third-party inspection data will be coded for inclusion in the Platform Inspection System of the Gulf of Mexico, OCS operations, to permit its retrieval separately from inspection data collected by USGS inspection personnel.

*The panel defined a third-party verification agent which is later recommended for structural verification.

Third-party inspections will not replace any portion of the present USGS inspections but will be an adjunct to them.

B. Definitions: Third-party inspectors are defined as either: (1) personnel employed by the operator who are not directly responsible for the operation they are inspecting and who report directly to management, or (2) personnel who are employed by an outside firm with which the operator or group of operators contract inspection services.

In January 1976, the USGS requested the National Research Council's Marine Board to provide a technical analysis and to recommend procedures for the review of the structural integrity of new fixed offshore structures. The purpose of the study was to:

° Determine whether or not independent third-party review of offshore structures would be of sufficient benefit to the USGS, the companies involved in the design, fabrication, and installation of offshore structures, the operating companies undertaking the recovery of offshore petroleum and gas resources, the public and the Congress, to warrant the time and costs involved;

° Determine, if the answer to the above is affirmative, the scope and detail that should be recommended for such review and further, to determine the availability of criteria, guidelines, and engineering standards for performing the review; and,

° Identify and determine the relative merits of alternative organizational concepts for certification.

The panel limited its deliberations to the problems of design, fabrication, installation, and maintenance of fixed, bottom-founded, offshore oil and gas structures, that is, production platforms permanently fixed to the seabed by means of piling, spread footings, or other means. (Steel Jacket, Pile Supported; Steel Tower, Pile Supported; Concrete, Gravity; Articulated, Buoyant; Concrete/Steel Hybrid; Tension Leg; Guyed Tower; Monopod.) Other aspects of offshore oil and gas operations, i.e., the existence of pipelines, drilling operations, production equipment, operational safety would be considered only

peripherally. Thus, mobile drilling ships and jack-up rigs were excluded from consideration.

The panel also excluded consideration of verification techniques applied to the structural integrity of existing platforms. A verification procedure for these must take into account the number of existing platforms, their age, the technology used at the time of construction, the cost of bringing them up to acceptable construction design criteria, specifications, etc., and the value of remaining oil or gas reserves. Thus, the large number of existing platforms and the differences in their ages would require an evaluation procedure entirely different than the procedure applied to new platforms.

An additional limitation which the panel imposed on itself was the consideration of costs. Ultimately, the public will bear the total costs of operating the system either through taxes or increased prices for oil and gas. Therefore, the panel generally considered only the total costs and did not attempt to differentiate between "government costs" and "industry costs" except when necessary.

Certification vs. Verification

One of the first tasks on which the panel focused was selection of terminology to define accurately the process they were studying. Accordingly, the implications of the words "certification" and "verfication" were examined. The panel concluded that while the term "platform certification" as presently used by the USGS refers to certification by a professional engineer "...that the structure will be constructed, operated and maintained as described in the application (of the owner/operator) and any approved modification thereto" the public and the Congress might infer that the structure was certified to withstand all environmental and man-made impacts upon the structure.[8] However, it is not possible to certify unconditionally that the platform will at all times be safe for operating personnel, or withstand the effects of all storms and seismic conditions, collisions or accidents, or that the environment will not be endangered.

Nevertheless, a procedure is required, whatever its designation, to assure the public, the Congress, the USGS and the owner/operator of the platform that the environmental and operating factors have been given consideration in the platform design, construction and installation. This

procedure should also indicate that appropriate reviews and inspections have been conducted to document that the design, building, and installation of a platform are in conformance with the applicable performance criteria, specifications, etc. This procedure has been identified as "verification."

Scope of Panel Study

The panel examined numerous areas of concern associated with verification, including:

- The overall objectives of verification;
- The adequacy of the present USGS verification system;
- The methodology and characteristics of other U.S. and foreign verification systems;
- The adequacy of present industry design, fabrication, installation, and maintenance practices;
- The legal and public-interest implications of verification;
- The need for, and the positive and negative effects of, any change from the present system;
- The criteria by which the verification system and organizational concepts might be judged for suitability and adequacy;
- Third-party verification process by which design review and inspection of structures is performed and documented by independent third-party agents. There are numerous variations of third-party verification systems. Some permit the utilization of personnel employed by the companies involved in the design and construction of the structure; other systems permit only the use of outside, independent qualified personnel or organizations as verification agents with a full range of combinations. In this report, several types of verification processes are discussed.

- The use of various groups -- USGS, and other government agencies, classification societies such as the American Bureau of Shipping (ABS), oil industry, engineering and construction firms, industry and professional societies, and independent consulting firms in a verification program.

The USGS also requested that the panel consider a study being conducted by the Aerospace Corporation, under contract to the USGS, as it related to the panel's efforts and to comment as appropriate. The Aerospace study analyzed various cerification procedures and developed detailed cost estimates, personnel staffing and implementation requirements. The USGS arranged for Aerospace to apprise the panel of its progress. The USGS also provided the panel with the Aerospace final reports, <u>Verification of Offshore Structures for Oil and Gas Development: Program Plan</u> and <u>Program Plan Implementation Options -- Verification of Offshore Structures for Oil and Gas Development</u>.[9]

Need for Verification

No verification system can offer unconditional guarantees of structural integrity or even of the complete adequacy of design and construction procedures. The most that it can accomplish is to assure a high degree of probability that adequate or appropriate procedures, technology, and materials have been utilized, and that no recognizable problems have been overlooked.

The panel found no indication of major technical deficiencies requiring a more stringent verification system to improve the integrity of offshore structures in the geographical areas where the majority of offshore structures now exist. They determined, however, that as oil and gas development extends into offshore locations more hostile than the Gulf of Mexico, and the design, installation and operation of such structures become more complex, a system is needed to:

- Give formal and additional assurance to the public and the Congress of the integrity of fixed offshore structures in all U.S. waters;

- Ensure a continuation of industry's excellent past performance as OCS operations are extended into frontier areas with harsher conditions.

Primary Implementation Considerations

The success of any verification system depends on sound scientific and technical knowledge and its documentation, and on qualified personnel.

Knowledge of Offshore Technology

R&D efforts by the U.S. offshore industry have been primarily responsible for the development of OCS technology to its present state of sophistication. The scientific and technical knowledge required to implement a verification system consists of:

- Environmental data, including atmospheric, oceanic, and geotechnical;
- Engineering properties of structural materials;
- Structural design;
- Response of structures to environmental loads;
- Fabrication technology;
- Inspection technology; and,
- Installation technology.

While the present state of scientific and technical knowledge provides a satisfactory basis on which to continue the development and regulation of the U.S. outer continental shelf oil and gas activities, it is essential that this basis is continually expanded and supported. There must be an uninterrupted flow of environmental data, sponsorship of background or basic research and a regulatory climate that is conducive to continued (or even enhanced) industry research and development efforts. In his paper prepared for the panel, Matlock listed some suggested opportunities for further research (see Appendix B).

Status of Technical Documentation

The technical documentation includes policy guidelines, the basic verification program plan, and the administrative and technical procedures, standards, environmental data, and manuals by which it is supported and implemented.

The documentation now in use for offshore structures differs among government agencies, industrial groups, and certification organizations. To date, the technology has been developed and continually extended in a large measure by the U.S. offshore industry. The documentation of this knowledge exists in several forms, including:

- ° Government regulations, such as the U.S. Code of Federal Regulations, USGS-OCS Orders, British Department of Energy Guidelines;
- ° Classification Society Rules, such as those of Lloyd's Register of Shipping, Det norske Veritas (DNV), American Bureau of Shipping (ABS);
- ° Quasi-public sets of nationally recognized standards, such as those of the American National Standards Institute (ANSI);
- ° General professional and technical codes prepared by professional and technical organizations such as, the American Institute of Steel Construction (AISC), the American Concrete Institute (ACI), the American Society of Metals (ASM), the American Society of Testing Materials (ASTM), the Fédération Internationale de la Précontrainte (FIP); and petroleum societies' recommended practices, such as American Petroleum Institute (API) API-RP2A (Recommended Practice for the Planning, Designing, and Constructing of Fixed Offshore Platforms);
- ° Industrial firm design procedures and practices; and,
- ° Technical literature.

In its study for the USGS, the Aerospace Corporation reviewed API-RP2A and indicated which areas of the state of technology were satisfactory and which areas could be improved.[10] While the panel does not entirely concur with their conclusions, the report does provide a starting point for improving the documentation of recommended practices. It is to be noted, however, that API-RP2A is cited in domestic and foreign government regulations as well as classification societies' rules and thus presents a fairly accurate picture of the state of knowledge of offshore technology as it is being applied.

The task of translating the technical literature into standards is not trivial. It requires the constant examination of the evolving technology, exchange of information within the offshore technology community, and the contінous translation of new knowledge into standards. The resulting standards can be selectively incorporated into the regulations through the Federal Register process which solicits comments from industry and the public prior to adoption of the change.

Personnel

The number, scope, and intricacy of the functions to be performed in a verification program dictates a need for personnel with outstanding technical capabilities in many areas. Their technical competence should be combined with strong managerial ability and sensitivity to the public interest. At the same time, such personnel should have a keen grasp of the role of the government, and the capability of the industry.

Verification Functions

The panel identified the functions to be carried out in a verification system:

- Establish environmental design and construction criteria and prepare basic implementing documentation of policy, regulations, standards, and personnel qualifications;

- Prepare detailed verification plans which list the criteria and procedures to be used in design, construction, installation, and maintenance and the various design review, inspection, test, and quality control activities;

- Check and approve (with modifications, if needed) the verification plans;

- Provide an appeal route for resolving conflicts;

- Implement the plan (i.e., conduct design review, observe tests, inspect fabrication and installation, and review various quality-control activities);

- Monitor the implementation;

- Operate the failure reporting and analysis system; and,

- Audit the overall implementation of the verification system.

REVIEW AND ANALYSIS OF EXISTING SYSTEMS AND AGENTS

Historically, verification programs have been instituted as a result of catastrophes to assure the adequacy and safety of hazardous structures or equipment. They provide the basis for obtaining insurance for liability or loss, and for obtaining government approval or licensing for construction and operations. Examples are:

- Ship Classification: Originally instituted for insurance purposes by Lloyd's of London and by the Ship Master's Association (predecessor of the American Bureau of Shipping [ABS]); and,

- The Boiler and Pressure Vessel Code: Originally instituted for insurance purposes by the American Society of Mechanical Engineers (ASME).

In both cases, verification systems have been adopted by various governmental agencies to assist in fulfilling their regulatory responsibilities.

The panel reviewed several verification systems currently used in the United States and other countries. In addition, the panel reviewed the three optional verification procedures considered in detail by the Aerospace Corporation in their report to the USGS. The following verification systems were considered by the panel:

Present USGS system for offshore platforms;

Present internal system for offshore platforms used by many elements of U.S. industry;

Present British system for offshore platforms;

Present Norwegian system for offshore platforms;

Present U.S. Coast Guard (USCG) system for ships and mobile offshore rigs;

Present Federal Aviation Administration (FAA) system for civil aircraft; and,

Three verification options proposed for USGS consideration by the Aerospace Corporation.

The panel also considered, in less depth, the systems used by the U.S. Army Corps of Engineers for dams and by the U.S. Nuclear Regulatory Commission for power reactors.

Present USGS System for Offshore Platforms

The USGS system is based on OCS Order No. 8. It allows for differing environmental conditions encountered in the Gulf of Mexico and the Pacific Coast offshore areas, but in each case, the Order requires that the structure be designed to withstand the maximum operational and environmental loads expected to be imposed on it.[11] It also requires that the adequacy of the design be certified by a registered professional engineer. OCS Order No. 8 calls for personnel from USGS regional offices to review the general arrangement of the structure, the sizes of the primary members, and the anticipated operational and environmental loads. Internal industry reviews, which are discussed in the next section, are not necessarily submitted with the documentation to USGS. However, such reviews are used by the certifying professional engineer to help in an evaluation of the adequacy of the design.

The USGS has evolved a system for issuing regulations. It solicits industry, government, and the public by publication of a proposed regulation in the Federal Register and requesting comments. USGS reacts to the comments prior to final promulgation of the regulation through the Federal Register.

As presently constituted and performed, the USGS system cannot assure the structural integrity of offshore oil and gas platforms in the harsher environments of the Arctic and Alaskan waters. It will take time to codify the experience being gained from other harsh environments, such as the North Sea, and it will require more experience and knowledgeable staff to apply it. Furthermore, although

the USGS system invites public participation, it does not provide for an effective appeals route. The lack of adequate criteria for the registered professional engineer who certifies the platform, further weakens the the credibility of the USGS procedure insofar as the public is concerned. The present USGS system has a failure-reporting and analysis function, but due to lack of staff, the analysis function is not strongly implemented. Formalized accident investigation and review, and system audit functions are not included.

Present Industry System of Design and Construction Review

The internal design review is conducted by specialists who have taken part in the actual design and construction work. The reviewers determine whether the design and construction meet accepted industry practice, the customers' requirements, and applicable codes, standards and practices. Independent re-calculations or re-analyses of the structure may or may not be conducted. The process is monitored and disputes are resolved by high level company officials. In Wartelle's paper, prepared for the panel, a schedule for a typical industry review is described, and appears in Appendix C.

In view of the public's wariness toward industry today, it would be naive to assume that the industry verification system would sufficiently assure the public and the Congress as to the structural integrity of offshore platforms and to the safeguards and precautions that are being exercised for protecting human life and the environment. However, the industry system undoubtedly uses its technical personnel more efficiently and effectively.

British System for Certification of Offshore Platforms

In Great Britain, the Department of Energy (DOE) is responsible for establishing certification requirements. The basic statutory regulations are amplified in <u>Guidance on Design and Construction of Offshore Installation</u>, published by the DOE in 1974.[12] Certifications and periodic recertifications of offshore structures are conducted by five ship classifications societies: Lloyd's Register of Shipping; Det norske Veritas; Bureau Veritas; American Bureau of Shipping; and Germanischer Lloyds. These organizations are appointed by the DOE to provide a "Certificate of Fitness" for each installation.

In addition, the DOE is presently appointing two additional certifying authorities which are a consortia of English and Scottish-based consulting firms. The certifying authorities have established their own rules and requirements within the general bounds of the government's statutory and guidelines regulations. Such rules provide the principal technical documentation in all areas except those dealing with environmental concerns. The rules are based upon experience as well as documents such as API-RP2A, the accepted British National Codes and Standards, and other widely-accepted codes and standards. Environmental conditions are described by the British weather service.

The system, based on observations of panel members, has negative characteristics. The Lloyd's or DNV review procedures (principal ones used) require costly independent re-computation of structural conditions. The DOE is reported to lack sufficient experienced competent personnel. As a result, the DOE cannot provide a strong monitoring activity nor perform an effective updating of regulations that stay abreast of technological advances. In addition, the British system does not provide an effective appeal route for disputes between the operator and the certifying authority.

The highly structured and detailed content of the rules of the British system, and its lack of flexibility discourages the introduction of new technology, and makes it difficult to design prudently and cost-effectively. The British system provides for an effective use of technical manpower by the verification agents (except for the structural re-analysis in the implementation steps of the system), but does not provide an appeal route or invite public participation.

Norwegian System for Certification of Offshore Platforms

The Norwegian system is similar to the British for certification and periodic recertification, except that less authority is delegated to the certifying authorities. The Norwegian Petroleum Department (NPD) is responsible for verification. The primary certifying authorities are Det norske Veritas and Dr. Aas Jacobsen and Associates (A-J). The NPD also enforces rather detailed occupational safety regulations, comparable to those of the U.S. Occupational Safety and Health Administration. While the NPD also provides environmental design information, the

primary structural rules are set by the certifying authorities. These rules, like those in Britian, are based on DNV experience, FIP recommendations, API-RP2A, applicable government standards, and other widely-accepted codes and standards. The DNV and A-J reviews also include an independent re-computation of the structural analysis. The NPD is better staffed than the DOE and thus is able to maintain a greater degree of monitoring and updating of regulations than the DOE.

The Norwegian system has demonstrated in practice considerable flexibility primarily because of the effective use of its personnel. Nevertheless, because it is highly structured and the rules are extremely detailed, the adoption of new technology may be difficult. The Norwegian system does not provide for public input.

The U.S. Coast Guard System for Certifying Ships and Mobile Offshore Rigs

The United States Coast Guard (USCG) has statutory responsibility for the certifying and periodic recertification of ships and mobile offshore rigs before these are fixed in place. The USCG has a strong in-house technical capability and provides detailed regulations and rules under which ships and mobile rigs are certified. These rules are developed through the Federal Register process. The American Bureau of Shipping (ABS) is authorized by statute to provide certain structural certifications based upon USCG and ABS rules.

The USCG participates in the development of ABS rules. The ABS structural rules for ships are the result of over a century of operating experience as well as technical analyses. As is the case for DNV, Lloyd's and A-J, the ABS also depends on an independent re-analysis of the structure in its review.

The environmental conditions are specified for ships and will vary depending on the "class" to which they are certified. The USCG operates a continuous mointoring, investigation, and review system to provide data about failure and accidents. Major accidents are formally investigated by USCG teams and their findings are reviewed by the National Transportation Safety Board (NTSB) to determine probable cause.

FAA System

The Federal Aviation Administration (FAA) has the statutory authority for certifying the airworthiness (structural)and operational safety of civil aircraft operating in the United States.[13] FAA rules and regulations are established after publication in the Federal Register. The technical base for the certification process of FAA is derived from in-house technical personnel and benefits from the expertise of the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD). In the FAA system, certification of a particular type of aircraft begins with a certification plan developed by industry based on FAA rules. Following approval of the plan by the FAA (often after modification), implementation is accomplished by Designated Engineering Representatives (DERs) and Designated Manufacturing Inspection Representatives (DMIRs) with the FAA monitoring and auditing. DERs and DMIRs are nominated by industrial employers and approved by the FAA. They do not review or inspect work for which they have been responsible.* The DERs and DMIRs review the design, quality control, and manufacturing inspection activities on those aircraft-types for which they have been qualified by the FAA. Their work is monitored and audited by FAA technical personnel.

The FAA operates an effective failure reporting and analysis system that provides information for improved regulations and for the determination of recommended or mandatory aircraft modification requirements. All major accidents are investigated by the FAA in conjunction with the NTSB. The findings of probable accident causes are then published by the NTSB. The results of these investigations and reviews are utilized in a continuing process of updating the regulations and improving airworthiness.

Proposed Aerospace Options

The three options considered by the Aerospace Corporation for USGS implementation are basically identical, except for the affiliation of the personnel performing the verification functions. Possible types of personnel and their affiliations are: employees of classification

*USGS places similar limits in their definition of third-party certification as published in the Federal Register, Jan. 29, 1976, and quoted herein on page 7.

societies, such as ABS, DNV, or Lloyd's; teams of personnel from offshore engineering, design, or construction firms who divest themselves of other offshore business to avoid conflict of interest; and designated representatives from industry.

The Aerospace Corporation recommends a verification procedure in which USGS personnel are charged with the development of the verification plan. The extent of the technical review undertaken through verification would depend on the degree of experience/knowledge of the design and construction procedures proposed and the expected environmental loading. In the Aerospace study, offshore structures are subdivided into six classes, based on combinations of existing, extended, or new technology and known or unknown environments.[14] These classes are:

Class A Units or structures of proven design in a known environment*

Class B Units or structures of proven design in an unknown environment**

Class C Units or structures of extended design in a known environment

Class D Units or structures of extended design in an unknown environment

Class E Units or structures of new design in a known environment

Class F Units or structures of new design in an unknown environment

The environmental conditions would be determined from a data base prepared and evaluated for the USGS by a contractor. The design and construction rules and regulations would be derived from existing applicable rules and codes.

*Known environment is that for which nominal and extreme wave and wind loads can be predicted with acceptable accuracy and seabed geotechnical characteristics are known.

**Unknown environment is that for which the above predictions are not substantiated with sufficient data and/or seabed geotechnical characteristics are not well known (latter applicable to seabed fixed units).

These, according to the Aerospace study, would be reviewed and augmented to cover harsh environments and all current design practices. The rules would be promulgated through the Federal Register.

The NRC panel notes that provisions were not included in the proposed Aerospace procedure for reporting and analyzing failures, investigating and reviewing accidents, auditing the entire process, or including such data and evaluations in the regulations and rules.

As described by Aerospace, the process appears to this panel to be quite detailed and rigid. The only flexibility provided is the choice among the six classes of verification. An appeals route is provided by which the USGS regional and area offices could resolve disputes. No reference is made to appeals by industry.

The panel identified a set of criteria as a result of its examination of each of the foregoing verification systems. Ideally, the verification should:

- Provide the public and the Congress with added assurance that industry development of the OCS is being pursued in an environmentally acceptable manner;
- Accommodate and encourage new technology, avoiding over-dependence on codes instead of good engineering;
- Be flexible and adaptable to frontier-area operations;
- Provide for an appeal route in contested determinations;
- Avoid introduction of undue delays;
- Provide for the most effective use of personnel with experience in design, fabrication, and installation of OCS structures;
- Minimize disruption to the USGS and industry operations;
- Provide time for the USGS to acquire and train staff; and,
- Facilitate "phased" implementation.

The panel determined that none of the existing systems entirely meet the basic criteria and institutional requirements for a verification system that would effectively assure the public and the Congress of the structural integrity of the new platforms. Continuation of the USGS system would be least disruptive for both the USGS and the offshore industry. The introduction of the other systems would be disruptive, at least temporarily, since all would cause marked changes from the present practice. The British and Norwegian systems would provide less disruption to industry (except for the associated acquisition of strong technical personnel by the government) since much of the U.S. offshore industry has already worked with one or both of these systems in the North Sea. As now constituted, all of the systems are sufficiently structured to recognize the time required to acquire and train personnel in a phased manner.

A RECOMMENDED VERIFICATION SYSTEM

As a result of the preceding analysis, the panel believes that a third-party verification system could be instituted and implemented by the USGS that would assure the public and the Congress that the best applicable scientific and technical knowledge available is being used in the design, building, installation, and operation of fixed offshore structures on the outer continental shelf. The panel has identified the elements of a verification system that it believes would enhance the capability of the USGS, but that would not be overly restrictive and rigid. The system is based on a combination of the desirable elements of the various systems reviewed by the panel, including the considerable wealth of experience already gained from operations in the Gulf of Mexico. Some modifications to procedural details have been introduced to accommodate the variety of environments, experience in operations, and types of structures used in OCS development. The resulting system should be sufficiently flexible to allow adaptation to other offshore facilities that might be used for OCS oil and gas development.

System Steps

The basic steps encompassed in the proposed procedure are:

1. The operator (person, firm, corporation or other organization employed by the owners [of a platform] to conduct exploration, production, and recovery operations) submits to the USGS the structure verification plan. The cost of implementing the verification plan is borne by the operator;

2. The USGS checks plan in-house (or with contract support in some cases);

3. The USGS approves plan if appropriate (an appeal route is provided for contested decisions);

4. The plan is implemented by the third-party engineering and inspection representatives as listed in the plan;

5. The USGS monitors implementation of the plan for compliance, provides an appeal route, and institutes a failure reporting and analysis system;

6. An independent board (similar to NTSB) conducts and/or reviews investigations of major accidents;

7. A step-by-step procedure for implementation and approval is provided to enable work to proceed in a timely manner.

Contents of Verification Plan

The verification plan submitted by the operator would describe the plan for design, construction, and installation in sufficient detail to identify those aspects that ensure platform integrity. These include:

- Definition of environmental performance criteria, which the structure must withstand (e.g., a 100-year storm);

- Design criteria and procedures, including probable names of designer and design consultants;

- Fabrication procedures, including probable list of fabricators;

- Installation procedures (conditions analyzed, such as launch, applicable pile-driving practices, etc.), including probable name of installation contractor;

- Operating procedures and plans for post-installation and maintenance inspection procedures that relate to structural safety (inspection intervals and coverage);

- Techniques and procedures to be used for verifying the structure: design review (engineering); tests (materials/welding); and inspection procedures (fabrication, installation); and,

- Nominations for the implementing third-party verification agents.

Applicable Verification Standards, Codes, Practices

The preparation and acceptance of verification plans should be based on applications of technology and engineering practices that have been developed for OCS operations under specific environmental conditions. These practices include those of:

- OCS Orders of the U.S.G.S.;
- American National Standards Institute (ANSI);
- American Society of Mechanical Engineers (ASME);
- American Society of Testing Materials (ASTM);
- The American Petroleum Institute (API);
- The Federation Internationale de la Precontrainte (FIP);
- American Concrete Institute (ACI);
- Society of Naval Architects and Marine Engineers (SNAME);
- Internal standards developed within individual organizations comprising the offshore industry;
- American Welding Society (AWS); and,
- other regulations and foreign standards as applicable to the specific structures for which the structure verification plan is submitted. e.g. Det norske Veritas Rules for Design, Construction and Inspection of Fixed Offshore Structures.

These practices, standards, and codes should appear in the Federal Register publication and as practicable, undergo ANSI review. In the rapidly expanding offshore technology, the system must be flexible enough to accommodate applicable advances as soon as they appear in technical society publications.

As new documentation on environmental design conditions and recommended practices for design and construction become available, it should be incorporated into design and verification programs, and when applicable, into the appropriate standards and design practices.

Repeated Designs

When the designs used are the same as those of previously verified platforms, the design review verification step should be minimized. However, the review should take into account planned structural modifications and differences in environmental loadings, if any.

Flexibility to Accommodate Advanced Designs

The need for flexibility in a verification system cannot be overstated. For example, the truly "frontier" structures will need design procedures and perhaps fabrication and installation techniques that may not have been applied to other offshore structures. They may require new procedures and techniques that have not been recognized in the documentation governing verification. Consequently, verification for such structures cannot rely on a literal interpretation of the then accepted and standardized guidelines, or wait while guidelines can be formulated through the Federal Register. Without flexibility, the new concepts needed in the design, building, and installation to meet conditions in more severe environments will be stifled.

Furthermore, it must be recognized that building a platform is a step by step procedure, spanning a long period of time. These steps include detailed geologic and oceanographic investigation of the specific site, establishment of the system concept for development of the field, design of the structure, fabrication of principal components, transportation and installation of the basic structure at the site, completion of installation of the drilling and production equipment, after which the drilling can commence. Over that period of time, design details are completed, with such adjustments as may be required. The verification system should be sufficiently flexible to accommodate these steps.

Inspection

The inspection component of verification pertains to both fabrication and offshore phases. Fabrication inspection will cover such items as welding and materials in order to confirm that the structure has been built to the approved design specifications. At sea, it is necessary to confirm that the platform has been installed according to plan and that critical damage to the platform has either not occurred, or if it has, that it has been adequately repaired. Such inspection may require the use of remotely operated television, underwater photography, nondestructive test equipment and procedures, and trained inspection divers.

Ongoing Configuration Control and Inspection Plans

Post-installation changes affecting the platform (configuration control) and inspection plans relate to the establishment of a "regime for safety" that should result in continued structural integrity for the operational lifetime of the structure until such time as it may be abandoned and removed. Such a "regime for safety" process includes: (1) ongoing configuration control; (2) planned periodic third-party inspections; (3) reverification either when changes in configuration are made which would affect structural integrity or when the inspections show that because of major damage due to ship collisions, marine corrosion, and storms, repairs are necessary.

Third-Party Verification Agents

To be qualified as an independent verification agent (design reviewer or inspector), the design organization or personnel selected may not have corporate affiliation with the owner or operator; nor should they verify any of the design, fabrication, installation, or operation functions which they or a corporate affiliate have performed for the specific platform being verified.

Third-party verification personnel may be independent consultants or may be drawn from the offshore industry and sources such as consulting firms, offshore engineering and inspection firms, and classification societies such as American Bureau of Shipping and Det norske Veritas. Verification reports prepared by these verifying agents are to be submitted by them to the government with copies to the operating companies.

Failure Reporting

Failure reporting and analysis should deal with repairs made following the planned routine or emergency-caused inspections, as well as with failures that occur (and are found) between inspections; the reporting can be implemented using the present USGS industry reporting system for safety devices.

Accident Investigation and Review

Accident investigation and review would occur only following major structural failures or other events as

necessary. The investigation could be conducted by either the USGS or USCG at the request of the USGS. Post-investigation review should be conducted by a detached high-level board such as the National Transportation Safety Board (NTSB). Review by such a board would provide a strong measure of credibility to the identification of the probable cause. Cost effectiveness should be high because of the past experience of NTSB and the infrequent occurrence of major structural failures.

System Management, Approval, Appeal, and Audit

There are a number of government functions not listed as a part of the contents of the submitted verification plan but critical within the overall verification system. These will include: management of the system, approval (disapproval), occasional appeal, and audit of the planned implementation.

The purpose of the auditing function is to assure the USGS that the verifying agents are, in fact, conducting the verification procedure systematically, completely, and totally in compliance with the verification plan. Spot checks may be required in which inspection techniques and inspection records are carefully examined and authenticated.

The provision of an effective appeal route is essential for settling disagreements encountered both in the verification plan review and in the implementation of the plan. Disagreements will, on occasion, be unavoidable because of the advancing nature of the engineering involved, the interpretation of the environmental data, and the lag in modifying codes, regulations, and standards which accommodate the technical advancements.

Analysis of Proposed System

The components of the proposed system are summarized in Table I which includes further explanatory notes on each. As was done on pages 15 to 22 for the existing systems and Aerospace options, the panel reviewed its proposed system with respect to each of the criteria and needs established earlier.

The proposed system, with its use of third-party verification agents and the accident review board (similar to NTSB), appears capable of assuring the public that the

TABLE I

STRUCTURE VERIFICATION SYSTEM OUTLINE AND NOTES

ITEM	NOTES
Verification System *Management* -General	-USGS is regulatory agency and arbiter and auditor. -Verification agents are generally from ABS, other classification societies, consulting firms, or other industries and sources such as American Welding Society-qualified inspectors. All of these are to be independent third parties as defined within this report.
-Failure Reporting and Analysis	-Procedures developed by USGS (possibly with contractor help) and promulgated by Federal Register route. -Reporting by industry with USGS monitoring. -Collection and analyses by USGS (possibly with contractor help). -Analyses can also be made of data by *USGS, industry, or other interested* researchers.
-Accident Investigation and Review	-Investigation conducted of major failures or accidents by government agency (USGS or USCG). -Review by government board (special board or NTSB). (Use of USGS and NTSB probably is most credible and cost effective approach).
Verification Plan Components -Environmental Performance Criteria	-USGS listing of conditions to be considered in each region, such as winds, ice seismic activity, etc. -USGS listing of how they are considered, i.e., as maximums from 100-year periods. -Can be developed for USGS by contractors and promulgated through Federal Register route.
-Environmental Conditions Operating Loads	-Industry or government or jointly collected data. -Applicable conditions submitted by operator and approved by USGS when defined as the design progresses.
-Design Procedures	-General Procedures specified by USGS, based on RP-2A and revisions, other standard codes, and OCS Orders. -Specific procedures, analyses, etc. selected by operator and approved by USGS (possibly with the help of contractors). -Application of procedures monitored by verification agents.
-Materials	-Selected by operator and approved by USGS.
-Fabrication plans (including inspection and quality control)	-Selected by operators and approved by USGS.
-Verification Design Review	-Conducted by verification agent with USGS monitoring and approval.
-Verification Inspection of Fabrication and Installation	-Verification agent selected by operator and approved by USGS.
-Post Installation Periodic Inspection Plans and Inspection	-Plans developed by operator with USGS approval. -Inspection by verification agents.
-Abandonment and Removal Plans	-Development by operator with USGS approval.
-Abandonment and Removal	-Conducted by operator-selected, USGS-approved contractors with verification agent inspection and reporting.

industry is developing the OCS in an environmentally safe and resource-conservative manner. Initially, as in any new program, there will be a short supply of USGS personnel qualified in offshore structure technology. This deficiency can cause intolerable delays should the system be instituted hastily.

Management Options

The panel believes that a verification system could be instituted which would correspond to the Management Option listed in Table II.

As will be noted, the functions marked by asterisks and identified as "establish criteria," "approve plan," "provide appeal route," "failure reporting and analysis," and "audit implementation" are considered to be primarily government responsibilities. The remaining functions are "prepare plan," "check plan," "implement plan," and "monitor implementation." The management options for these functions should be balanced against considerations of credibility, accountability, and cost.

The panel believes that the operator is the best qualified to prepare the plan ("prepare plan") according to government guidelines since the industry will design, fabricate, and install the platform. Also, since the structure is owned and operated by the operator, it is in the best interests of both government and industry that the accountability reside with the operator.

The plan, once prepared, ideally would be checked for technical and administrative adequacy by the USGS personnel before approval; however, if the USGS checked all of the industry plans in detail, it would require a large staff of highly competent, technical manpower, whose work load would fluctuate considerably. Therefore, it may be more efficient for the USGS to contract for the actual checking process for selected submissions or portions thereof. The use of contractors to check all plans is possible, but unwise, since the USGS must develop and maintain a strong in-house overall technical and management capability in the performance of its verification functions. For these reasons, the USGS, with contractor assistance, is indicated as having responsibility for the "check plan" function (USGS/Contractor). To assure credibility and accountability, contractors in the "check plan" function should be drawn from sources other than those industrial sources involved

TABLE II

Matrix of Options for Performance of Verification Functions

Function	Possible Management Options		
	1	2	3
Establish Criteria*	USGS	USGS	USGS
Prepare Plan	Industry	Third Party	Third Party
Check Plan	USGS/ ** contractor	USGS/ contractor	Contractor
Approve Plan*	USGS	USGS	USGS
Provide Appeal Route*	USGS	USGS	USGS
Implement Plan	Third Parties	Third Parties	Third Parties
Monitor Implementation	USGS/ contractor	USGS/ contractor	USGS/ contractor
Failure Reporting* and Analysis	USGS	USGS	USGS
Audit Implementation *	USGS	USGS	USGS

* Functions considered to be Government responsibilities

** USGS/contractor means, USGS personnel undertakes part of the function and may use contractors to assist for selected defineable portions.

in the design, etc., of the structure involved.*

The "implement plan" function will require the maximum number of capable personnel. If this function is performed by the USGS, a large staff would be necessary, particularly to handle peak-activity periods; furthermore, scheduling the government personnel to inspect, review, etc. could impose considerable unwanted delays. This function, however, can be carried out by industry, using qualified verification agents with the necessary skills who may be individuals or companies that have no corporate affiliation with the owner/operator of the particular structural platform being verified. The operator's choice of third-party verification agents would be submitted in the verification plan for the USGS approval.

A highly competent USGS staff will be necessary to monitor the implementation function properly ("monitor implementation"). By using monitor contractors, the size of the staff can be kept to a minimum; however, the USGS auditors should be used to spot check the entire implementation program.

The utilization of other agencies such as the Navy and the Coast Guard in the verification process was considered by the panel. For example, the USCG experience which could be applied to parts of verification include:

- Safety of life at sea;
- Pollution cleanup;
- Effective relationships with groups such as ABS, technical societies, Intergovernmental Maritime Consultative Organization (IMCO);
- Ship certification;
- Failure and accident investigations; and,
- Ongoing USCG marine engineering research and ship operations.

*It is not believed necessary nor advisable, as indicated in the Aerospace options, for the consulting firms to divest themselves of other offshore design and engineering work to be qualified for such effort. In fact, the overriding requirement is for the expertise that can only be developed by being technically involved.

The assignment of a group of USCG technical personnel might be considered for a two- to five-year period to aid in the verification system while a permanent USGS staff is formed. As the USGS competence was developed, the assigned USCG staff would be terminated.

Separation of the development and regulatory functions by assignment of the latter to another agency to ensure public credibility was discussed by the panel. However, in view of the statutory basis for the USGS, which is discussed later, and the fact that meaningful regulation is dependent upon the understanding of the associated technology, this option may not be feasible at this time.

REQUIREMENTS FOR ESTABLISHMENT OF PROGRAM

A great amount of effort will be required by the USGS to institute a valid third-party verification plan. Besides the sizable task of recruiting personnel, numerous implementing documents must be developed including a substantial policy guidance document. It is also necessary that industry shift to independent reviewers and inspectors. This will understandably cause a certain realignment of expertise within the industry and will take time.

Transition Period

The industries that are affected by a verification program are those that are involved in the exploration, production, and recovery of petroleum and gas resources. These include designers, builders, and operators. Their primary concern is not with the concept of structural verification, but rather with the potential problems resulting from a system that is poorly conceived or administered. The panel identified the negative effects that could occur if a verification system is adopted too hastily, such as delays in the updating of regulations; use of inadequate criteria or an appearance of "waivers" or "exceptions" in the application of the system; an overdependence on "following codes" rather than "good engineering." It noted that opposing views of regulations by individual verifying agents or regional offices would have a frustrating effect on operators, designers, and builders, and that technical development could be inhibited due to the lack of technical competence or lack of experience of verifying agents or USGS approving officials.

By establishing a transition period with specified time-linked milestones to be reached during this period, government and industry can proceed in an orderly manner to the implementation of a full third-party verification program designed to avoid these pitfalls.

While it is important to assure that the implementation of the third-party verification program is established in an orderly manner, it is also necessary that the continuity of the development of offshore energy is not unduly interrupted or delayed by the verification implementation process. The

USGS, the Congress, the Executive Branch and their budgeting offices, and industry must take appropriate actions, particularly with respect to the USGS personnel requirements and third-party verification agents to minimize the delays.

Many of the milestones to be achieved during the transition period are readily evident by reviewing the program policy document outlined in Appendix D. In fact as will be noted, the policy document itself will take considerable time to develop and may undergo modification during the transition period as the USGS gains the necessary management staff.

Table III outlines the requirements for the orderly establishment of the ultimate third-party verification program in relation to the transition period. These requirements are discussed in the following paragraphs.

Board of Consultants

A board of consultants should be named by the USGS at the beginning of the transition period and become an integral part of the third-party verification program. As noted in Table III, the board would perform a variety of functions on a continuing basis. It would guide the USGS in the development and review of proposed environmental design conditions and construction practices (by geographical area and structural type) and provide recommendations for verification procedures, and for the qualifications of third-party reviewers. It is important that this board is in place and functioning before the USGS issues environmental design conditions and construction practices for third party and industry use in a given area of OCS operations. The USGS, however, would be responsible for the final decisions.

Because of its function and close working relationship with the USGS, the board must reflect a high level of technical knowledge from industry, academia, and government, and it must also reflect the needs of the public. The board need not be made up entirely of technical experts.

Program Policy Document

This document is considered to be necessary to ensure consistent, logical enforcement throughout the several USGS regions.

Table III

REQUIREMENTS FOR ESTABLISHMENT OF VERIFICATION PROGRAM

Item Needed	Description of Needs and Sources of Information and Assistance	
	Notes and Transition Steps	Third Party System
1. Program Policy Document	Necessary to insure consistent, logical, enforcement. USGS can adopt outline based on one provided herein as an interim document.	USGS should develop document based on outline provided herein. Can use Regional Office help in developing document. Board of Consultants*should assist USGS management in reviewing policy before it is promulgated by Federal Register Route** to assure broad input.
2. USGS Regulation Requiring Verification of Structural Integrity	Legal Necessity. USGS can publish an "Intent to adopt regulation using outline based on present recommendations as "interim regulation"."	USGS should develop Proposed Ruling based on recommendations provided herein; and should use Board of Consultants* and Federal Register Route** to assure broad input.
3. Recommended Practices (Design Procedures, Standards, Codes, etc.)	Necessary part of system. USGS can include in publication of "Intent to adopt regulation" and "interim regulation" noted above in Item 2. Material can be taken, as appropriate, from existing versions of OCS Order #8.	USGS should use Board of Consultants* and USGS contractors to develop these from the Recommended Practices, Specifications, Standards, and Codes not in existence. They can then be promulgated using the Federal Register Route.** These items can then be updated and amended as needed by the same process as the system develops in actual operation.
4. Environmental Design Conditions (for design and operation)	Same as for Item 3	USGS should use Board of Consultants* and USGS contractors to develop these from the best currently-available information, and promulgated by the Federal Register Route.** They can then be updated and amended as needed. These conditions should be specified only in terms comparable to "100-year storms" and not in terms of specific wave heights, etc. The specific numbers will be a part of the plan submitted and approved for each structure and need not be specified in the regulations if the reviewing, verifying, and approving personnel are truly competent.
5. Qualification Standards for Third-Party Personnel	Necessary part of system. USGS can begin with simple requirements for: "Registered Professional Engineer or qualified companies with experience in design of offshore structures" and "Qualified Inspector with experience in inspection & quality control in construction of offshore structures." Both should be "Third Parties" as defined by USGS in Fed. Reg. of Jan. 29, 1976.	The final qualification standards should also be developed by the Board of Consultants,* and promulgated through the Federal Register.** Third parties are individuals or companies having no participation in design, fabrication, installation or operation of the platform to be verified or corporate affiliation with companies who do.
6. Internal USGS Procedures	Essentially same as for Item 1.	Essentially same as for Item 1.
7. Acquisition and Training of Personnel	50 to 100 offshore engineering related personnel to be recruited or arrangement for services obtained. Establish contract (s) with university (ies) or other sources for intensive overview and detailed offshore technology courses pertinent to verification.	Continuation of transition period efforts

*Board of Consultants should consist of eminent personnel in practice, drawn from academia, industry, and the public. It should be used on a continuing basis to update Items 1 through 6 as needed.

**"Federal Register Route" consists of: Publication of proposed document or regulation in Federal Register; Receipt and response to comment (written or public hearing) from all concerned parties; and Final Promulgation by publication in Federal Register.

The final document should be reviewed by the board of consultants and then published in the Federal Register to assure broad input and wide acceptance. In the transition period, an abbreviated interim version could be published in the Federal Register. An example of such a document was prepared for the panel and has been included as Appendix D.

The USGS staff should seek advice of the board of consultants and others to aid in the preparation of a credible schedule for transition milestones. Program progress will dictate the necessity for adjustments to the transition milestone dates, and depend not only upon the USGS efforts, but also upon appropriate funding and the recruitment of key technical personnel.

Early development and publication of the program policy document and transition milestone dates and the achievement thereof is necessary to assure the government, the Congress, and the public of the viability of the transition period as well as the succeeding third-party verification program.

Requirements Regulation

A regulation requiring a verification plan for each OCS structure is a legal necessity. The USGS should develop a Proposed Ruling based on the recommendations provided herein; and should use the above-noted board of consultants and the Federal Register publication process to assure broad input. As with the program policy document, the final document can be developed with assistance from the USGS Regional Offices.

Recommended Practices, Design Standards, and Codes

The USGS can adopt, by reference, the various Recommended Practices, Specifications, Standards, and Codes now cited in existing OCS Orders using the Federal Register process. It must be noted, however, that some of these documents are incomplete, contradictory, out-of-date, sometimes too explicit, and sometimes too vague. As a result, their literal application would stifle design and construction. The effort demanded by step 3 of Table II (p. 32) to get procedurally satisfactory documents is considerable. Technically, the available documents, when coupled with engineering judgment, are adequate as guidelines; but, they are not adequate as documents for verification. These items can be updated and amended by the board of consultants through the same process as the system develops.

Environmental Design Conditions

Some specification of the environmental conditions which the structure must withstand is needed. The USGS can begin with the "conditions" now specified in the various versions of OCS Order No. 8 as part of the adoption of "Procedures" noted above. This should be updated and amended as soon as feasible using the board of consultants. These conditions should be specified only in terms of general conditions such as 100-year storms, ice loadings, and seismic activity. Unusual geological conditions such as subbottom faulting, potential slumping, and turbidity currents may be pertinent to the particular offshore areas and addressed in the verification plan. They would have also been addressed in both the pre-leasing studies by the Bureau of Land Management (BLM)/USGS, as well as in petroleum drilling and wellhead completion operations. The specific numbers of data such as wave heights and amounts of ice or the particulars for obtaining such data will be part of the verification plan submitted for each structure. Being site specific, they would not normally be specified in the regulations. Competent specialists will be necessary for reviewing, verifying, and approving the environmental data to be used as the conditions for design. This area, among others, requires continuing research.

Qualification Standards for Third-Party Verification Agents

In reviewing the availability of third-party verification agents the panel considered, in depth, the potential sources of technically qualified agents.

As a standard engineering practice, the operator and the industry contractors conduct design reviews and inspect the quality of fabrication. To accomplish this, expertise has to be drawn from in-house teams as well as from outside contractors and consultants.

Since the personnel nominated by operators to conduct the actual verification (review and inspection) functions are subject to approval by the USGS, standards must be established for their approval. During the transition period, the USGS can begin with simple requirements such as "Registered Professional Engineer with experience in design of offshore structures," and "Qualified Inspector with experience in inspection and quality control in construction of offshore structures." Verification agents may be from the applicant's firm, provided they have not been directly involved in performing the work being verified. From initiation of the transition period, "third parties" or firms

as defined by the USGS in the Federal Register of January 29, 1976 should be used when possible. By completion of the transition period, only independent third parties or firms should be selected for each particular structure. Professional standards would be the standards amplified during the transition period by the board of consultants, and promulgated through publication in the Federal Register.

Internal USGS Procedures

The requisite internal USGS procedures for implementing the system can be developed in essentially the same manner as described for the program policy document. However, since these are internal procedures, they can probably be developed initially in a slightly more informal manner.

The USGS Personnel

Many skills requiring experience in offshore operations are integrated into the design of a safe and efficient platform system. The system is designed to meet a multitude of factors such as drilling and production and environmental conditions as well as fabrication and installation techniques. Verification programs require a combination of experience, technical training, and management skill of all personnel in order to be effective.

It is evident, therefore, that in addition to regulatory and verification management ability, the USGS should have personnel possessing skills in the following disciplines:

Drilling Technology	Construction Engineering
Geology	Installation Engineering
Geophysics	Marine Engineering
Geotechnical Engineering	Materials Engineering (concrete)
Hydrodynamics	Materials Engineering (steel)
Ice Engineering	Naval Architecture
Meteorology	Production Engineering
Oceanography	Quality & Inspection Engineering
Seismology	Structural Engineering (concrete)

Statistics

Structural Engineering (steel frame)

Systems Engineering

Welding Engineering

Acquisition and Training of the USGS Personnel

Recruitment should be immediately initiated for an acknowledged leader in offshore structure technology possessing management skills and a keen sensitivity to the interaction of the structure with environmental factors.

Recruitment should follow for other senior specialists and managerial skilled offshore engineers with the realization that it will take a significant amount of time. Contracts to gain additional support for specific efforts would be contingent on sufficient in-house expertise to monitor these efforts properly.

The USGS will need to recruit from the offshore industry and its supporting contractors in order to obtain personnel with the appropriate experience. It will probably be necessary to work closely with the Civil Service Commission so that sufficiently high ratings are available for those who meet the stringent qualifications that will be required. The USGS may also wish to consider other methods to find such talent:

° A government-industry personnel interchange program;

° Arranging an assignment of qualified personnel from other government agencies;

° Contracts with various segments of the supporting offshore consulting, servicing, and classification organizations; and,

° Arranging temporary hiring of academic personnel knowledgeable in offshore engineering.

Other Personnel Considerations for the USGS

The overall success of the verification system depends not only on the competence but also on the continued dedication of its personnel. The USGS personnel will have, through the verification process, a significant impact on

offshore oil and gas production. Therefore, it is incumbent upon the USGS that its personnel maintains its competence, enthusiasm, and objectivity by active participation in the various verification functions, close contact with supporting research and development activities and participation in appropriate technical society activities.

Since not only senior level experienced offshore engineers will be recruited but also engineers who have other applicable experience, it will be necessary to initiate intensive training courses in offshore technology. (An example of the breadth and scope of training applied to another aspect of oil field operations has been detailed for the panel by Rupert C. Craze in Appendix E.) Engineering colleges that have curricula with a heavy concentration of offshore courses as well as various segments of the offshore industry should be consulted for training programs that would reflect new technologies, operations techniques, and scientific knowledge.

Intergovernmental Agency Cooperation

Although the USGS will have primary responsibility for the verification system, it will need the cooperation of other government agencies to initiate the program. In particular, the Civil Service Commission should be consulted at the outset so that the USGS has the flexibility to employ the highly qualified people it will require. In addition, the Office of Management and Budget should be apprised of the need, scope, and details of the system, so that the USGS can benefit from their advice on its implementation.

Research and Development Implications

Despite the need for continuing revision and formalization, the present design procedures, standards, and codes are deemed satisfactory for initiating a verification system. This is evidenced by the record of structural integrity of existing offshore structures. However, with the extension of platform construction into harsher areas, design and construction procedures, standards, codes, and environmental conditions will require continued research support from both industry and the government. The verification system should utilize the existing procedures and standards as a starting point. The formal specification of environmental design conditions should receive priority because the task is far from simple and requires lead time to collect critical data. Both now and in the future, this

will involve quantification of environmental conditions for design purposes, determination of acceptable intervals of extreme occurrences, and determination of minimum design requirements either for extreme loads or for complete load spectra.

Determination of the appropriate loads based on specific conditions and intervals is another R&D priority. Further, the quantified load values are subject to revision as additional environmental data are acquired and as improved methods are developed for conversion into energy forces. Many of the current design procedures and standards are in the process of revision and will continue to be revised in the foreseeable future.

LEGAL CONSIDERATIONS

The USGS has the authority to regulate oil and gas structures with respect to protection of the environment and the conservation of natural resources on the OCS. However, as oil and gas operations move further from shore and into harsher conditions the protection of human lives will become a greater problem since many platforms may be continuously manned, during periods of both calm and high seas.

Today, the USGS's major detailed regulations concerning the safety and integrity of offshore structures are found in OCS Order 8, which refers to 30 CFR 250.11 and .19(a) as authority. Part 250 of the Code of Federal Regulations refers in turn to the legislative mandate in the Outer Continental Shelf Lands Act (OCSLA), 43 USC 1334, as its statutory authority. OCSLA authorizes the Secretary of the Interior, and by delegation, the USGS to:

> prescribe and amend...rules and regulations... as may be necessary and proper in order to provide for the prevention of waste and conservation of natural resources of the Outer Continental Shelf and the protection of correlative rights herein...
> (43 USC 1334) (a) (1).

Thus the key language on which the USGS's authority to require verification rests is that of waste, conservation, and correlative rights, not safety. There is a question as to whether the language can be interpreted to cover the protection of human life, as well as of the environment and safety of the structure that the panel considers to be vital. Contrast, for example, the statutory language of the Coast Guard's safety responsibilities for the same structures. The Coast Guard has the authority to make and enforce regulations:

> ...with respect to lights and other warning devices, safety equipment, and other matters relating to the promotion of safety of life and property...
> (43 USC 1333) (e) (1).

Another possible statutory base lies in section 1333 (a) (1) of the OCSLA, which extends the laws of the United States to all oil and gas artificial islands and fixed structures on the outer continental shelf. The Mineral Leasing Act of 1920 (30 USC 21 *et seq.*) provides that the USGS, by delegation shall have authority:

> ...to prescribe necessary and proper rules and regulations and to do any and all things necessary to carry out and accomplish the purpose of this chapter... (30 USC 189).

The USGS thus has a clear mandate for safety on land that would cover the verification program. The general language of section 1333 might be interpreted as providing an extension of the mandate oceanward. And, existing regulations in 30 CFR Part 221, Oil and Gas Operating Regulations, provide ample scope for safety and environmental concerns of verification. However, following section 189, there is an explicit statement that rules and regulations with respect to tracts on the OCS leased for mining are to be prescribed by the Secretary, *citing* the familiar section 1334 of OCSLA.

The adequacy of the legislative mandate to the USGS with respect to human safety is thus open to question. A practical issue is whether it is likely to be challenged in court. If industry plays a part in the setting of the standards and establishment of the verification procedures, and is reasonably content with the outcome, it is unlikely to challenge USGS authority. Public interest groups might challenge the authority as well as the substance, if they thought the USGS authority was inadequate, and if they believed pressure on Congress might result in a tougher perspective. Until this issue has been clarified, exercise of the USGS current safety oriented activities in response to its "conservation" mandate provides a basis for designing (and probably implementing) the verification scheme.

COST CONSIDERATIONS

Costs associated with verification systems can only be approximated; for example, it is difficult to determine the added costs industry must absorb with a separate design review conducted by a third party. In some cases, industry might elect to use the results of certain portions of a third-party verification to satisfy parts of their internal review requirements. In most cases, they will probably elect to undertake separate in-house reviews.

Another important consideration affecting costs is the number and complexity of platforms to be constructed. It has been estimated that about 25 major platforms will be built in new U.S. waters per year in the coming five years. The costs can range from $30 million to $150 million each, depending on their size, the site of installation, and the objectives of the platform. Also, the additional costs assignable to verification to obtain environmental data, whether incurred by industry or government, would be difficult to establish.

A verification system might result in a "saving." For example, a third-party review process may assure that one or more structures survives a storm. On the other hand, the verification system could add to costs by delays that could result in shifting the installation of the structure to the next weather-suitable construction season. Thus, an accurate and totally defensible tabulation of real costs is unattainable.

The panel's best estimate of the cost of a verification program is approximately one percent of the total platform cost to the USGS for personnel to administer and monitor the system, and two percent of the total platform cost for industry, to cover its costs for extra documentation, reviews, and inspection.

CONCLUSIONS

Although the record of safety for offshore platforms has been excellent, the panel finds that the proposed third-party verification program for new offshore platforms will enhance the orderly extension of OCS oil and gas activities in an expeditious and efficient way by assuring the public and the Congress of the integrity of the fixed offshore platforms. A secondary benefit will be a more uniform application of current technology. Specific conclusions follow:

- ° A commitment by the USGS for sufficient, qualified personnel is required for initial and later implementation of the program.

- ° A transition period is needed during which time the verification procedure is established in order to avoid disruption of the present orderly development of the OCS and to utilize existing technical experitise fully.

- ° While a verification system can provide documentation that design, fabrication, installation, inspection, and maintenance is in compliance with applicable criteria, guides, specifications, and codes, it can reduce, but not entirely eliminate, the possibility that a structural failure may result from conditions caused by the environment or man.

- ° An ineffective or poorly executed or overly detailed and rigid verification system can introduce inordinate delays that may disrupt the orderly development of energy resources on the OCS, and may even increase the probability of accidents.

- ° There are four major functions of a verification system to assure that performance criteria are met: systems

management; establishment of environmental conditions, design and construction procedures; promulgation of recommended practices for design and construction; and implementation of the verification procedures. No organization or agency, as presently constituted, is entirely suitable for implementation of the total verification system or for providing the systems management function.

- The management of verification needs to reside in the USGS and not be delegated; the environmental design conditions and recommended practices for design and construction should be established by the USGS (utilizing input from industry, professional societies, universities, individual experts, and public groups). The implementation of verification procedures should be delegated to independent third parties nominated by the operator and approved by the USGS within appropriate guidelines.

- The presently available technology (design procedures, standards, codes, and environmental data) is capable of supporting the initiation of an adequate verification system for the U.S. OCS platform locations. However, there are two critical factors in implementing the proposed third-party verification program:

  (a) Consolidation and documentation, on a continuing basis, of:

  -- environmental design conditions,

  -- recommended practices for design and construction,

  -- qualifications for third-party personnel, and

  -- verification implementation procedures.

(b) The availability of personnel with technical capability and experience in offshore practice to support the associated effort, both in government and industry.

- Immediate requirements for the initiation and operation of a verification system are:

  ...adequate staffing in the USGS with qualified personnel to carry out the management function;

  ...establishment of a board of consultants.

  An adequate transition period is considered essential. The fully independent verification system should not be initiated until the USGS has the capability to manage it, and the associated policy, codes, specifications, and procedures needed for implementation of the system.

- In view of the difficulties likely to be encountered as offshore technology is applied in harsher environments, the current level of onoging research and development in industry and government must be sustained and preferably raised to maintain and enhance the status of the technology.

- The USGS verification personnel must be encouraged to participate in activities that will result in maintaining and updating their technical competence. Government personnel training through a cooperative program within the industry, such as is practiced by the U.S. Coast Guard and several other agencies, as well as specialized courses from universities having strong curricula in offshore structure engineering, can help maintain technical proficiency. In addition, the USGS personnel should be encouraged to participate in professional society activities and conferences in the U.S. and overseas.

- The adequacy of the USGS statutory basis with respect to human safety on structures which may remain manned during storms needs clarification.

RECOMMENDATIONS

Based on its study of the needs, benefits, costs, and probable effects of verification, the panel recommends that a third-party verification system be implemented by the U.S. Geological Survey. This recommendation is made with the recognition that a significant commitment of effort and funding by the USGS and the industry will be required to ensure an effective and constructive system.

To aid in establishing and operating the system, the panel offers a series of recommendations, many of which are interdependent. In planning and executing a verification system careful consideration of each element should be taken to minimize delays created by the procedure. The system must be flexible and adaptable in operation to accommodate new technical developments and the time-consuming step-wise process of designing, building, and installing a platform.

(1) A policy document should be prepared by the USGS to initiate the verification system. The document should establish that the primary goal is to enhance the orderly extension of oil and gas activities in an expeditious and efficient way by assuring the public and the Congress of the integrity of the fixed offshore platforms. The document should define the elements of the verification system and the policy by which the system is implemented.

(2) The principal elements that should be included in the verification system are:

(a) establishment of environmental design conditions for each offshore area and each class of structure,

(b) documentation and promulgation of recommended design and construction practices,

(c) submission and approval of verification plans,

(d) verification of design, fabrication, installation, and enhancement of safety through continuing periodic inspections,

(e) issuing of approvals and a permit to operate,

(f) a rapid and effective procedure for appeals, and

(g) provisions for auditing.

(3) The USGS should establish a continuing board of consultants composed of representatives from industry, academia, the public, and government sectors, to develop and review environmental design conditions and practices (by geographical area and structure type), verification procedures, and qualifications of third-party reviewers.

(4) The USGS should provide guidelines for submitting acceptable verification plans for individual projects. Such plans would be initiated by the owner or operator and should describe environmental and operating conditions under which the structure must maintain its integrity; the proposed design, fabrication, installation, and maintenance procedures; descriptions of the scope of the design reviews, inspection, and testing; and identification of individuals or organizations who will act as the third-party reviewers.

(5) For each project, the following general procedure should be applied:

(a) The owner or his representative submits a verification plan in accordance with the USGS guidelines recommended in (4).

(b) The USGS accepts the submitted verification plan or issues a statement concerning specific corrections required.

(c) Third-party review and inspection is done in accordance with the accepted plan.

(d) The USGS acknowledges compliance with the verification program with written approval and issuance of a permit to operate.

(e) For cases in which plans or verification practices are contested, an appeal procedure is established by the USGS, possibly through the use of an ad hoc technical panel or the board of consultants.

(f) Provisions would be incorporated for step-by-step verification and approval, thus allowing actual work to be initiated in a timely manner.

(6) The USGS should directly manage and administer the verification system. Although the board of consultants will make recommendations about the system and individual consultants may be utilized in reviewing verification plans when submitted, the USGS should not delegate its authority and responsibility for establishing environmental design and construction conditions, practices, and verification procedures. This also should apply to approvals of individual verification plans, their implementation, and appeals.

(7) The panel recommends that, to be qualified as an independent verification agent (design reviewer or inspector), the design organization or personnel may not have corporate affiliation with the owner or operator; nor should they verify any of the design, fabrication, installation, or

operation functions or parts thereof which they or a corporate affiliate have performed for the specific platform being verified. The verification agent may thus be drawn from such groups as consultants, engineering companies, and verification societies such as ABS and Det norske Veritas, provided they meet the particular technical and the independence qualifications.

(8) The shift from the present USGS system to the implementation of the verification system should be accomplished in an orderly manner, taking into consideration the critical shortage of qualified personnel, the intergovernmental agency cooperation that must be established, and the time required to initiate an effective and useful system. The USGS should establish immediately the board of consultants and develop environmental design and construction practices. During a transition period, an owner or operator could continue to use existing recommended practices and applicable codes, pending the adoption of new ones by the USGS. During this transition period, in-house design approval by a professional engineer in lieu of third-party verification could be continued, although owners and operators of structures should be urged by the USGS to progressively increase their use of independent third parties for verification, thus phasing out the present USGS system.

(9) Only when the USGS is staffed adequately and environmental conditions for specific regions have been established, should verification procedures shift from those used in the transition period to those recommended for full third-party verification.

(10) It is to be expected that significant technical questions will arise from the verification process. The USGS should take positive steps to insure that necessary research programs are initiated.

(11) Procedures for routine reporting of platform structural conditions and analysis should be established. The reporting can be implemented using the present USGS reporting system for safety devices.

(12) Accident investigation and review should be undertaken to determine the probable cause of major structural failures, or other events as determined to be necessary. Such investigations should be reviewed by a board similar to the National Transportation Safety Board.

(13) The USGS should aggressively organize and develop a highly competent staff in order to establish and operate the verification system. Positions must be established with civil service ratings of sufficiently high grade levels to attract highly qualified and competent engineers to undertake the program. Prior experience in offshore work is vital for these key people.

(14) The USGS personnel involved in the administration and management of the verification system should be encouraged to participate in technical societies and in other groups concerned with OCS activities.

(15) Adequate funding for the management and administration of the verification system needs to be assured by the federal government prior to its implementation.

(16) Provision should be made by the USGS for periodic review by an independent group of the efficacy and deficiencies of the established verification system, with appropriate action recommended for alleviating each deficiency.

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APPENDIX A

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APPENDIX B

THE RELATION OF RESEARCH TO CERTIFICATION

HUDSON MATLOCK

In the present consideration of certification of offshore fixed platforms, primary emphasis has been placed on frontier areas. For frontier areas, the need for gathering new knowledge and for the development of new and innovative engineering methods is obvious. Even in established areas such as the Gulf of Mexico, there is a continuing need for extension and refinement of existing technology.

Three distinct areas of investigation should be recognized:

(1) acquisition of environmental data and understanding of pertinen processes and effects,

(2) development of methods for analysis, design, and construction, and

(3) observation of performance as a basis for refining correlations between (1) and (2), for improving engineering methods and for continuing review of codes and regulations.

History of Cooperative Research

The world-wide construction of offshore platforms during the last three decades constitutes a truly remarkable achievement. In terms of rapid and massive development of technology and especially of benefits to mankind, it is interesting to compare it to the conquest of outer space.

The research and development which provided the basis for the accomplishment have had an interesting history. The earliest platforms, in relatively shallow water, were extensions of onshore marsh area capabilities, for the most part on a company-by-company basis. In the fifties, there were attempts at organizing jointly-supported research efforts in such areas as wave forces, structures and foundations. However, it soon became evident that a more expeditious and effective process resulted when one company provided the leadership for a particular research effort and

then offered the results on a cost-sharing basis to others. This practice continues to the present time, although in the last few years the participation has broadened greatly, with projects typically involving 10 to 15 companies. Along with a broader base of support for the research has come more rapid and widespread dissemination of the results. With regard to fixed-platform technology, management groups in most companies have come into agreement with technical people that proprietary interests are minimal and that it is very desirable to have rapid dissemination through such vehicles as the Offshore Technology Conference. Some of this attitude can be attributed to the desire to provide a rational basis for anticipated development of codes and regulations.

Research for offshore platform design has been characterized by a high degree of objectivity on the part of the sponsors. For the most part, the companies supporting the research are also the owners and are looking for technically sound solutions to difficult problems.

Public Interest and Responsibility in Research

Perhaps oversimplified, the justification for certification of offshore structures appears to rest on the public interest in enhancing recovery of resources and in protecting against environmental damage and injury to personnel. With regard to the necessary development of knowledge and engineering capabilities, there appear to be two possible approaches: (1) continued development by industry alone or (2) joint efforts by government and industry. If only to provide a basis for certification and regulation, it appears that the second choice is more likely. Currently, government agency efforts and government contract research funding are applied in the national interest to many other segments of our economy.

Government efforts would appear to be best applied in providing environmental data on a broad scale and in sponsoring background research. Particularly for frontier areas, the private sector must be free to provide the innovative solutions required for new and unusual problems. On the other hand, any groups involved in the certification of structures also should be closely involved in the knowledge-development process in order to keep abreast of current developments.

All parties should be cooperatively involved in the ongoing study of performance. This must not be limited to periodic safety inspections. A great deal can be gained

for the future by monitoring earthquake, wave, wind, and other natural phenomena correlated with the observed performance of structures. Provisions for measurements should be considered in the original design of structures. In view of the present state of knowledge, primary emphasis should be placed on simple and reliable check-point types of observations, and overly elaborate instrumentation schemes should be avoided.

Finally, procedures must be developed to accelerate the exchange of all environmental data, research on methods, and observations of performance.

APPENDIX C

McDERMOTT HUDSON ENGINEERING

TECHNICAL WORK REVIEW - STRUCTURAL

T. R. WARTELLE

A. INTENTION

1. Prevent structural failures and monetary loss to McDermott and our customers.

2. Improve Quality of Design.

   a. Ensure design is in accordance with the criteria.

   b. Ensure design is in accordance with current standards and codes.

   c. Ensure design can be fabricated and installed on most economical basis by our construction divisions.

   d. Ensure designed structure and/or system functions properly in field.

3. Develop consistency of work to ensure design by various departments is in a standardized form best suited for use by our construction divisions and customers.

4. Ensure continuance of education of personnel in latest codes, standards, and construction techniques.

B. APPROACH

1. Consider review of equal importance with initial design.

2. Review items that affect structural adequacy, performance, and/or ability to construct.

3. Review only and do not redesign, since responsibility remains with initial designer. Only constructive criticism is sought.

4. Schedule review so that original design is generally complete before it begins. Review may be in phases or in one package depending on particular project requirements.

C. TYPES OF REVIEWS

1. No Review

    a. The work involved is so minor that no review is warranted.

    b. The structure is not designed by one of the corporation engineering departments.

2. Routine Review

    a. The structure involved is a type or design that has been performed frequently and does not have any special or unique problems associated with it.

    b. The primary emphasis is in comparing the key design, fabrication and installation parameters with those of previous projects.

    c. The comparison normally is completed by technical review personnel in the New Orleans Technical Review Section.

3. Intermediate Review

    a. The structure involved is the first (a prototype) of a new series of modified platform components, such as a new deck type. The structure involved also may have an unusual fabrication and/or installation procedure, such as projects involving drilled-in piling.

    b. A thorough review is performed of the structural analysis model and/or the computerized structural analysis input and output with emphasis on the unique areas of the design. This is in addition to the work performed in a routine review.

    c. The intermediate review normally is completed by an engineer in one of the three Structural Design Departments (New Orleans, Wembley, Houston), or the Special Projects Department in New Orleans office. The only limitations on the selection of this engineer are his experience,

availability, and non-involvement in the original design.

4. Major Review

    a. The structure involved has difficult and/or unique design, fabrication, or installation procedures.

    b. A thorough review of the entire design is performed in sufficient detail to satisfy the reviewer of the adequacy of all aspects of the design. This is always in greater depth than an intermediate review.

    c. The major review normally is completed by an engineer in one of the three Structural Design Departments (New Orleans, Wembley, Houston), or in the Special Projects Department in the New Orleans office. The only limitations on the selection of this engineer are his experience, availability, and non-involvement in the original design.

Obviously, placing portions of a given project into the above types of review requires discretion by the structural design engineer and his supervisor. Also, the review types descriptions provide guidelines and are not all encompassing.

D. <u>INFORMATION FLOW PROCEDURE</u>

1. The project is received by the Engineering Department and a project engineer is assigned.

2. As soon as possible thereafter, the design (and/or project) engineer notifies the Work Review Section via the project engineer of the following:

    a. A description of the project.

    b. The type of review required for each review category subject to supervisory discretion.

    c. The schedule for the review.

3. Based on this information, Work Review selects (in conjunction with Review Contacts in the different offices) the engineer(s) who will be performing the review.

4. When the design is ready for review, the review materials are forwarded directly to the reviewer by the designer(s).

5. Once the reviewer receives these materials, he acknowledges their receipt and indicates if he can meet the desired review schedule. Work review scheduling conflicts are jointly resolved by Work Review and Review Contacts.

6. The reviewer then proceeds with the review. All technical questions concerning the review materials are resolved directly between the respective designers and reviewers.

7. Upon completion of his work, the reviewer forwards his review findings to the designer, project engineer, Work Review Section, and managers of the structural departments.

8. As soon as possible after receiving the review, the design engineer forwards:

   a. His answers and actions taken with respect to the review to the reviewer, Work Review Section, and to the managers of the structural departments.

   b. To the reviewer, any additional or revised calculations that have been added to the design file if he and his supervisors feel additional review is warranted.

9. The Work Review Section completes its records and advises the Work Review Technical Committee of any unresolved difficulties or unique happenings.

10. The Work Review Technical Committee then takes whatever action deemed appropriate.

APPENDIX D

OUTLINE OF PROPOSED PROGRAM POLICY GUIDANCE DOCUMENT FOR OCS STRUCTURAL VERIFICATION PROGRAM

PREFACE

Purpose: To provide common general requirements and policy guidance for a program of verification of structural integrity for fixed oil and gas platforms in all USGS OCS regions.

Basic Philosophy: To institute an effective program for such verification that: will provide added assurance to the public of the safe USGS and industry development of OCS resources; best utilizes the available technical competence in the U.S.; introduces a minimum burden upon both the USGS and industry in its implementation; and provides for broad public, government, and industry input to the regulations.

Policy: The policy of the USGS shall be to institute and implement a structural verification program that: is consistently applied throughout the several OCS regions; rests on a sound technical basis recognizing differences in the environmental conditions; is flexible and adaptable to OCS frontier areas; does not hinder safe OCS resource development on a reasonable time scale; is based on performance-oriented regulations; and encourages the development and use of new technology.

Approach: The approach of this document is to outline and briefly discuss the basic policy of the USGS in developing and implementing an effective program of structural verification of offshore facilities. The outline includes the relationships of the USGS to:

- Other concerned Federal and State agencies;
- The offshore oil and gas production industry;
- The supporting service industries who conduct structural design, fabrication, installation, and maintenance of offshore facilities;

- ° The various sources of standards, specifications, design codes, etc.;
- ° The various sources of verification agents for the conduct of design reviews, inspections, etc.; and
- ° The public and its representatives.

The detailed content of implementation plans and management plans for the verification system are the subjects of other documents.

INTRODUCTION

Scope: Fixed, bottom-founded, oil and gas platforms in the U.S. OCS. (May be wise to include statements on possibly extending scope later to include all OCS safety and pollution-control activities; i.e., everything covered in Gulf of Mexico OCS Orders #1 thru #10 and maybe #12.)

Approach*: The approach of this program will be to depend primarily on USGS monitoring of industry's adherence to a pre-planned and USGS-approved plan for the design, fabrication, operation, inspection, and maintenance of each new OCS oil and gas platform. In its monitoring, USGS will depend upon competent third-party personnel to conduct design reviews and to conduct or monitor quality-assurance programs and inspections.** The program will be implemented in an orderly, phased, manner; and will depend initially upon existing technology, design procedures, criteria, standards, etc. These technology elements will be reviewed and updated first as necessary to assure that they conform to the USGS program policy enunciated in the preceding section, and then only when determined on sound technical bases to be necessary for improving the structural integrity of OCS oil and gas platforms.

General Relationships and Responsibilities:

(Policy; not detailed procedures, etc.)
Relation to other USGS regulations and requirements.
Relation to other Federal regulations and requirements.
Actions and prerogatives of the Government:

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*This particular approach is based on the Panel's proposed Verification System. If some other system is selected, the approach description would, of course, be different.
**As defined in OCS notice to lessees, etc., Federal Register, January 29, 1976.

General USGS rights to data, etc.;
Proprietary rights of industry;
Third-party evaluations (use of, and approval of, third parties); and
Inputs to Government R&D and data-exchange programs.

Actions and Prerogatives of Industry:

Proprietary Rights;
Participation in R&D and data-exchange programs;
Responsibility for subcontractors;
Actions and prerogatives of third parties;
Access to data and records.

Reference to Glossary of Terms.

DOCUMENTATION:

(Emphasis on <u>policy</u>; <u>not</u> on details of content, etc.)

Types -- Statutes, Federal Regs., OCS orders, criteria, standards, API specs, stds., and RP's, etc.
Sources & Approvals -- Use of Board of Consultants for development and Federal Register Route for final promulgation.
Periodic revision & update -- Revise only as necessary, and only with sound technical basis.

PROGRAM MANAGEMENT:

(Policy on authorities and responsibilities)

USGS-Hq, Regional, and Area Offices (including appeal routes).
Assistance for Board of Consultants.
Industry.
Third parties.
Third-party qualification.
Training -- USGS, third parties, industry.
Interagency activities -- R&D and data exchange.

VERIFICATION ENGINEERING:

(<u>Policy</u> on responsibilities of USGS, industry, et al.)

General.
Environmental design conditions.
Design, construction, and inspection procedures.
Standards and specifications.
Failure reporting and analysis.
Requirements for Safety.

VERIFICATION OPERATIONS:

(Policy on responsibilities of USGS, industry, et al.)

Industry plan development -- General contents, include nominations of third parties.

USGS Plan Approval -- include approval of third parties.

Industry, USGS, and Third-party activities.

Accident Review.

APPENDICES:

Glossary of Terms.

Reference to USGS Regulations, etc.

Reference to other Federal Regulations, etc.

USGS-required documents.

Related Documents.

GENERAL NOTES (not part of document)

Be sure to cover the policy basis for deciding:

- Who does what, when, to whom;
- How to select third parties;
- General content of industry submittal (not too specific, but yet enough to assure uniformity);
- Specs and standards -- Performance-oriented, how to start, where to get later.

Some portion of document should explain policies on:

- Grandfather clauses -- how to treat existing platforms -- (mainly periodic inspection with time based on past history; minimum update of plan when major changes made in structure or loads [review only new engineering, etc.]);
- Varying depth of treatment based on prior experience;
- Basing all decisions on sound technical data and reasoning; not on personal preference;
- Review and appeal route.

APPENDIX E

AN EXAMPLE OF AN OFFSHORE TECHNOLOGY TRAINING PROGRAM

by

Rupert C. Craze
Petroleum Engineer

INTRODUCTION

If the USGS is to be responsible for the verification of offshore structures, it must have personnel competent in offshore technology. Such verification will involve personnel working with industry and academia to develop practical criteria for efficient design, construction, installation, and maintenance of integrity for oil and gas platforms, in both the development and operation phases. The more competent the government personnel are in these offshore-related engineering disciplines, the more efficient the agency will be. Fewer management tiers and thus, fewer personnel will be needed. Criteria and regulations developed will be more realistic and less complicated; corresponding documentation that industry must submit showing compliance will also be simpler, thus completing the loop and easing the communications between government and industry.

The design, construction, installation, and operation of offshore platforms involve skills in a wide diversity of disciplines in the technical and management areas that are not presently characteristic of the USGS staff. A need exists, therefore, for a comprehensive training program in offshore technology to provide rapid transfer of knowledge in the subject to existing and new USGS personnel.

A major approach to imparting the necessary expertise to the USGS personnel is through the medium of saturation learning process; i.e., a rapid training program involving the latest developments in all areas of offshore technology.

DISCUSSION

Training Program Needs

A training program should be designed specifically for those USGS personnel (present staff and new hires) whose chief responsibilities are in the areas of developing, managing, and implementing a verification program for offshore systems. The program should be a cooperative effort of the USGS, academia, industry, and consultants. The courses should be designed to transfer the latest and most efficient technology developed by industry in the offshore field. The curriculum should include broad overview courses for all the appropriate USGS personnel. This should be followed by a group of concurrent intensive courses in each of several disciplines pertinent to offshore structural design, constructions, and verification. Each USGS "offshore" staff member would take courses, related to the discipline for which that person would have responsibility.

As an adjunct to the above more formal and saturated course of instruction, further training might be implemented by the following:

- Loan of industry personnel to the USGS on a temporary basis, working with USGS personnel to guide them on the job and train them as instructors in further courses given in the offshore area.

- Transfer of USGS personnel on temporary loan to industry in specific areas to upgrade their expertise and to view industry activities at first-hand, with on-the-job experience.

- Maintenance of a liaison "faculty" to provide a constant awareness and ability to analyze and utilize the results of continuing industrial and academic research developments in the field of offshore technology.

- Participation of USGS personnel in the relevant activities of the several technical societies, such as the SPE (AIME), the Offshore Technology Conference, special study groups, and consulting organizations active in this field.

Example: Saturated Training in the Petroleum Industry

The training program described in the following presents the background, philosophy, and logic that led to the presentation of several highly-successful concentrated courses developed for in-house use by petroleum industry personnel.

The initial course covered the field of reservoir engineering and was designed to teach competent petroleum engineers engaged in field operations the basic fundamentals and latest reservoir technology developed by research. The course was designed for rapid transfer of highly technical knowledge to the operating petroleum engineers who were responsible for the efficient development and operation of oil and gas reservoirs. The goal to be achieved by the reservoir engineering course was the logical and practical application of the most up-to-date research developments in reservoir engineering so that the operating engineers might apply these developments to maximize the recovery of hydrocarbons from the underground reservoirs in an efficient and economical manner. A secondary goal was to impart to the operating engineers a sufficiently high expertise in reservoir engineering so that they in turn could serve as "faculty" themselves in an on-going program of instruction in the subject to incoming petroleum engineers. In this fashion the continuing developments in production research were blended with the practical knowledge obtained from actual applications in the field. This process expanded and updated the course coverage for utilization on a broadened base to all of the engineers involved in the operation of the diverse reservoirs encountered.

Over a period of time, this course has had considerable impact, not only in the operational reservoir engineering aspects, but also in such areas as well completion, well spacing, and efficient well operations. It further influenced the exploratory efforts, and had considerable impact on the technical foundations upon which governmental agencies promulgated their regulatory programs, working with industry to achieve a realistic conservation effort to produce oil and gas most efficiently.

Development of the Subject of "Reservoir Engineering"

Early research conducted by personnel of one of the major oil companies in the area of production research, beginning in the late 1920's and in the 1930's, both in the laboratory and in the field, established some very

fundamental principles relating to the behavior of fluids in oil and gas reservoirs and to a preliminary knowledge and understanding of the performance of those reservoirs. During this period, it was recognized that detailed studies of the performance of oil reservoirs had considerable value in direct application to field operation. Obtaining these benefits, however, required developing a comprehensive exposition of the fundamental principles governing reservoir behavior in order to transfer the accumulated knowledge to the using personnel.

A detailed report was prepared (in book form) that presented these fundamental principles governing reservoir behavior as established by research to that date. This report was given wide distribution among the operating elements within the company, as well as among research personnel. Of course, many of the subjects included in this report had been presented by the company's researchers in technical papers presented to and published by the several technical societies to which they belonged. In that fashion, this knowledge was also made available to industry as a whole.

It was during the period leading up to the publication of that report in 1940 that a new science had gradually evolved in petroleum production engineering. This new science was designated "reservoir engineering;" it became an integral part of petroleum production engineering, and it dealt principally with the movement of fluids in and the recovery of fluids from oil and gas reservoirs. It might be pointed out in passing that petroleum research organizations of several oil companies and in various universities were concurrently investigating various aspects of the subject of reservoir and well performance and were publishing papers that added much to the available knowledge of this specialized technology. Thus, reservoir engineering grew in importance as a vital tool that could aid the petroleum production engineer as he put this new science to practical use in the field.

Formation of a "Reservoir Engineering" School

With the stimulus provided by the Production Research Division's outstanding work during the 1930's in developing some of the methods of analyzing reservoir behavior, studies of several oil fields demonstrated the practical feasibility of applying these methods of analyses to actual field operations to improve recovery of oil and gas. The onslaught of World War II, and the attendant increased demand for

petroleum, brought to the forefront the necessity for operating each oil reservoir at its maximum efficiency in order to supply the war demands for petroleum and its products. This led to an increasing volume of work necessary to conduct technical analyses of each reservoir to obtain high operating efficiency. This work-load problem was compounded by the losses of technical men to the armed forces. It became readily apparent that the remaining few petroleum production engineers who were familiar with the reservoir engineering techniques could not handle the increasing volume of work effectively. To alleviate this shortage of technical men, plans were made in 1944 to train some of the outstanding petroleum engineers in other divisions in the subject of reservoir engineering by means of a concentrated program of transfer of available knowledge in the technology of reservoir engineering as developed by research. The first course of study included seven students for a three and one-half month period beginning in late 1944. Lectures and work sessions on applicable field problems were continued on a full-time basis for the entire period of this course, known as the first "Reservoir Engineering School."

Later, as these first "students" began to apply the results of their training to field operations, it became apparent that this type of reservoir engineering training was very profitable. Plans were soon made to enlarge the group of production engineers having such training. As a consequence, the Reservoir Engineering School has been continued to the present time in concentrated fashion at annual intervals, with the class sizes enlarged to include an avarage of 30-40 technical personnel. As successive Reservoir Engineering Schools were conducted, it became possible in greater degree to utilize as instructors many of the petroleum engineers who had attended earlier schools and who had attained a high degree of competence as practicing "reservoir engineers." Of course, the initial organization continued to supply instructors in subjects in their particular areas of competence.

Throughout the entire succession of Reservoir Engineering Schools, every effort has been made to update the course content to reflect the latest developments in reservoir engineering technology emanating from both research and operations within the company, from developments published by others in the industry, and from published advances in reservoir engineering within the academic world.

The experience gained with the first Reservoir Engineering School indicated the need for a Reservoir

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Engineering Manual for use both in subsequent training work and as a guide for reservoir engineering work throughout the company operations. A tentative manual was completed in time for use by the third class in its study program. Following this third class, the manual was completely revised and printed. Subsequent revisions and increases in the scope of the manual's content have been made to include up-to-date developments that have evolved in reservoir engineering technology. These revisions in the manual incorporated the latest thinking and experience in all the various facets of study material utilized, and made the manual an important text-book adjunct in the presentation of the course and in its further use as a guide and reference in practical field application.

In the late 1950's, the rapid advances made in the area of reservoir engineering made it apparent that additional training should be given to many of the practicing reservoir engineers who had already attended the prior regular schools. Accordingly, plans were made to upgrade the skills of these engineers through attendance in an "Advanced Reservoir Engineering School." The course of study was intense in its training and covered the most recent developments evolving from research and practical field experience. These schools were scheduled according to the needs at the time and proved quite successful in improving the proficiency of those who participated in this advanced training.

Establishment of Training Programs in Other Technical Fields

The success of the "Reservoir Engineering School" program exerted considerable influence among technical personnel engaged in other areas of activity throughout the company's operations. With the experience gained from the format of reservoir engineering training, the company embarked upon similar programs of instruction in the areas of Production Operations, Drilling and Well Completion Practices, Well Log Interpretation, and other facets of company operations. These schools were designed to transfer the latest developments in the respective areas of study to operational personnel including production engineers, drilling engineers, geologists, and geophysicists throughout the company. These schools likewise have greatly enhanced the skills of the operating technologists and have proved highly successful.

Other Means of Training Technical Personnel -- as Continuing Education

In less formal and concentrated approaches in training, the approach has been used of transferring competent engineering and scientific personnel on a loan basis from one area of technical endeavor to another area in order to give on-the-job training to personnel in needed skills. For example, the field engineer may be transferred to work with a research group to supplement his practical knowledge, and the reserach man may be sent to the field to gain a realistic approach to field operational problems. The use of consultants as highly-competent specialists in their field of endeavor who are brought into contact with research and operating people has been very successful as another medium of transfer of technology. Another training procedure has been the effective use of university professors to present short but highly-concentrated instruction in fields of their particular competence to selected classes of research and operational personnel as in-house courses in needed areas of skills. In reverse fashion, technical personnel may attend courses given at various universities to acquire additional training in specific areas. Other methods of upgrading the expertise of company personnel reside in an active participation in the various technical societies; presenting papers, attending meetings of these organizations, attending special courses and study groups sponsored by the societies, and becoming actively involved on special committee assignments, both technical and administrative. It is through these society activities and programs that a high degree of effective interchange of technical know-how is achieved.

CONCLUDING REMARKS

The history, planned format, practicability, and successful operation of the "Reservoir Engineering School" exemplified in the preceding discussion appear to offer considerable aid to the development of a concentrated transfer of knowledge in offshore technology to the personnel of the USGS. It is the sincere hope that this presentation, based on actual industrial experience, may prove to be helpful to those responsible for developing a course specifically designed to meet the needs for rapid training of USGS personnel.

APPENDIX F

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